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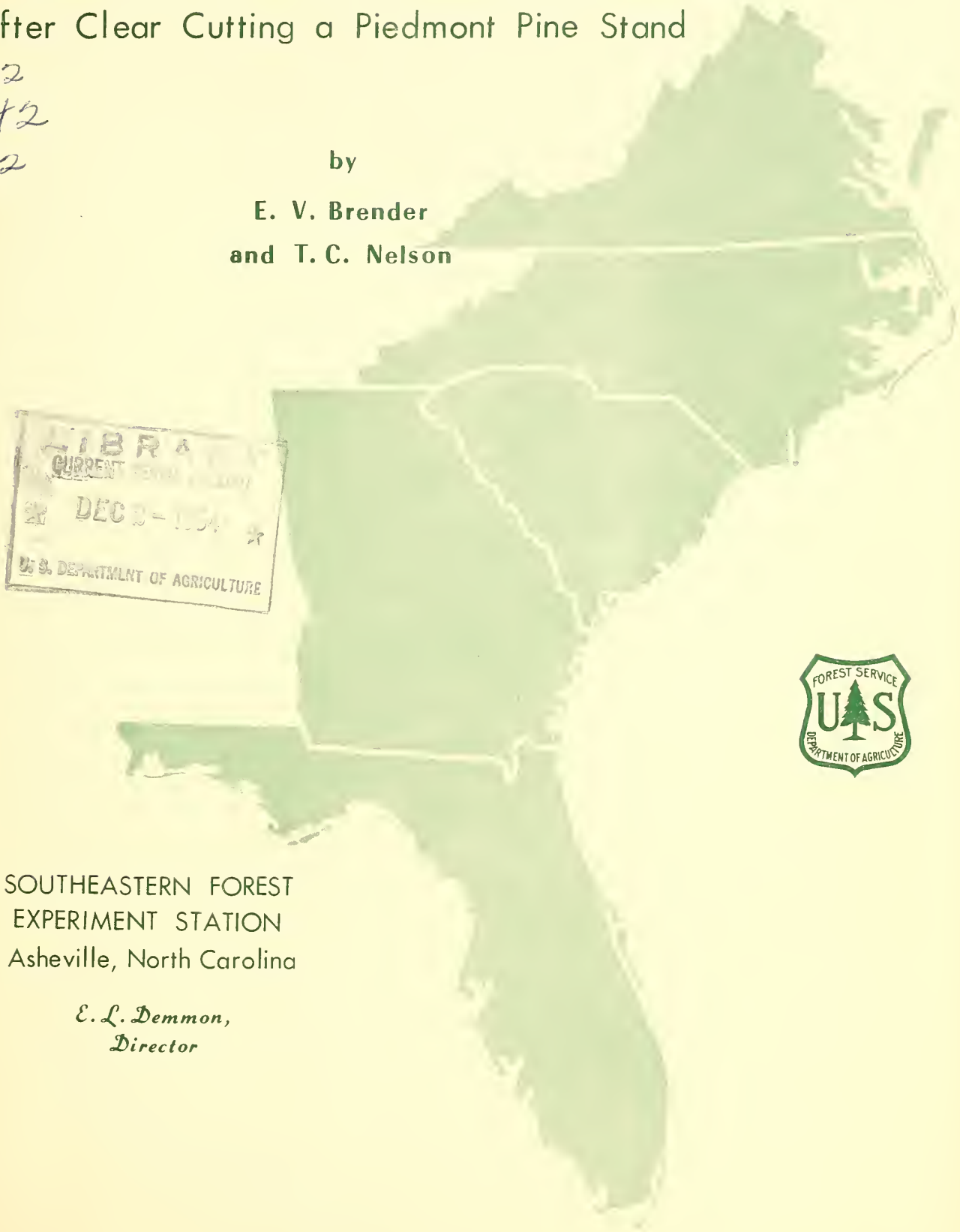

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BEHAVIOR AND CONTROL OF UNDERSTORY HARDWOODS AFTER CLEAR CUTTING A PIEDMONT PINE STAND

by

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In colonial days the silt loams overlying the clay soils in the Piedmont region of the South supported extensive hardwood forests. Most of the land was cleared and cultivated in cotton until the boll weevil and severe erosion made continued cropping unprofitable. Abandoned lands seeded to pine, but hardwood species have gradually made their appearance under the pine, following the usual trend of ecological succession. As the sites gradually improve, the hardwoods become more numerous and thrifty, making it difficult to regenerate pine stands on much of the land after cutting.

A study was made in north-central Georgia in a typical cutover pine stand with a hardwood understory to measure the rate of hardwood invasion, the reaction of hardwood species to release, and the effectiveness of cutting, burning, and grubbing as control measures in reducing hardwoods. A knowledge of understory hardwood behavior is important in establishing and maintaining pine on about one-half of the upland pine sites in the lower Piedmont, where hardwoods threaten to become dominant.

The most important factor governing the competition offered pine by hardwoods after cutting the overstory is the spurt in hardwood growth and thus the enlargement in area shaded by them. Other factors of importance are the number of hardwoods, the height of their crowns, and, because they are important in control, the growth characteristics of individual species groups. These subjects were considered in the study.

DESCRIPTION OF STUDY AREA AND TREATMENTS

The study was carried out in the Piedmont region of Georgia on privately owned lands in Walton County near Athens.[1] The area prior to clear cutting supported a 90-year-old stand of shortleaf pine with understory hardwoods consisting chiefly of oaks, hickories, gums, and shrubby species. The understory hardwoods were small, mostly in the 1-inch diameter class. They directly shaded 19 percent of the ground. The stand was located on a southerly exposure with approximately a 10-percent slope. It extended from near a ridge top to a short distance from a creek. Figure 1 shows location of the study area.

The overstory of pine on the study area was clear cut in February 1946. Control treatments were applied to the understory in February and March. The treatments, lettered to correspond with the plot diagram in figure 1 were:

Treatment A, control (repeated also as "Treatment E")

Treatment B, partial brush cutting and burning. All hardwoods 2 inches d.b.h. and larger were cut, the brush piled, and the area broadcast burned.

Treatment C, complete brush cutting. All hardwoods were cut and the brush left as it fell.

Treatment D, complete brush cutting and grubbing. All hardwoods were cut and root collars and major roots grubbed up.

The study was planned and conducted primarily as a test of preplanting treatments, and the study area was planted to slash and loblolly pines when the treatments were completed. The major practical results of the study concerned the effect of the treatments on the survival and growth of the planted trees. These results have been reported and anyone interested in the applied aspects of the study should consult the earlier publication.[2]

1/ This experiment was started by Archie Patterson, assisted by Burley Lufburrow, both formerly of the Southeastern Forest Experiment Station, in cooperation with the landowner, Bannon Jones of the Casulon Estate, and with the School of Forestry of the University of Georgia. Later work on the study was conducted by various members of the staff of the Hitchiti Research Center.

2/ Brender, E. V., and T. C. Nelson. Re-establishing pine on Piedmont cutover land. Southeastern Forest Expt. Sta., Station Paper No. 18. August 1952.

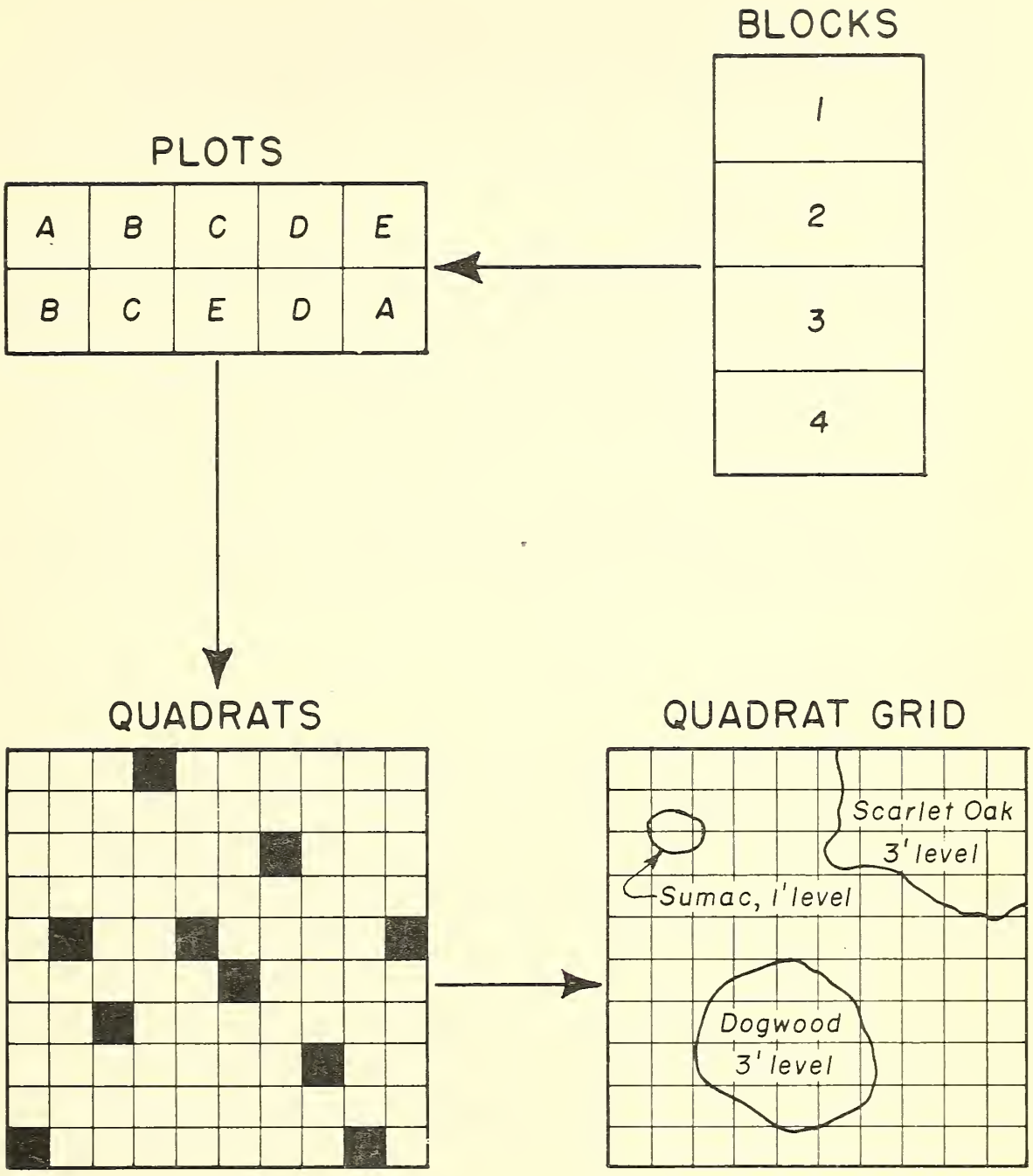

Figure 1.--Study area in the Piedmont region of Georgia, showing layout of blocks, randomized plots within blocks, milacre sampling quadrats within plots, and a 100-unit grid for a representative quadrat.

The present paper is a more detailed ecological report of the reaction of the hardwood understory to the control treatments listed above. It will be of interest mainly to research workers in the fields of hardwood control and the ecological aspects of forest regeneration.

Design of the Experiment

The design of the experiment in the field is shown in figure 1. The study area was divided into four split blocks in such a manner that the longitudinal axis of each block was along the contour. Within each of the eight half blocks there were five 1/10-acre plots to which five treatments were assigned at random. Thus a total of eight replicates per treatment was available for observation. On each individual plot, 10 square quadrats each 1 milacre in area were selected from the 100 possible quadrats, and used for detailed measurements. The permanent milacre quadrats were selected in such a way that one milacre quadrat would appear in each column of the plot with the row selected at random (fig. 1). The area shaded and number of stems were determined on the permanent quadrats at the end of the first, second, third, and sixth growing seasons.

Method of Measurement

On each quadrat, detailed crown maps were made showing the ground area covered by the crowns of various species, and the level of their crowns above the ground. Vertical crown projections were measured by a grid-mapping system, with the aid of a milacre quadrat frame divided into 10 units on each side. Thus, when placed around the permanently staked quadrat, the frame provided a guide for ocular mapping. As a further means of increasing accuracy, actual mapping of the crown profile was done on a tally sheet with a 100-unit grid system superimposed upon the quadrat outline.

The average level of the shade-casting branches was ascertained by an ocular estimate of the point on the tree or shrub at which the crown was widest. Then, with the aid of a graduated rod, the height was measured and recorded in 2-foot interval classes. Measurements were taken on the crown nearest to the ground if a tree or shrub grew under the crown of another.

In the analysis of the data it became evident that the hardwood species could be grouped on the basis of tolerance, their place in the successional trend, and density of shade. Consequently, five species groups were set up as follows:

Species group	Major components of the group
1. Shrubs	Sumac, hawthorn, wild plum, viburnum
2. Oak-hickory	Water, southern red, white, post, and black oaks; hickories
3. Intolerant hardwoods	Sweetgum, blackgum, yellow-poplar, white ash
4. Miscellaneous hardwoods	Persimmon, black cherry, mulberry, sassafras, elm, red maple
5. Tolerant, small hardwoods	Dogwood, serviceberry, holly

BEHAVIOR OF UNDERSTORY HARDWOOD FOLLOWING CLEAR CUTTING

CHANGES IN AREA SHADED

The logging operation itself temporarily reduced hardwood shade cover because of breakage by felled trees and mutilation from skidding logs; immediately prior to clear cutting, hardwoods shaded 18.8 percent of the area, but one year later only 15.8 percent was shaded.

By the end of the second growing season, however, 28.2 percent of the area was directly shaded by hardwoods and shrubs. Thereafter, the rate of increase was slower. In the third year, 31.5 percent of the area was covered. And during the next three growing seasons the area shaded increased to 34.9 percent, which brought the total to slightly more than double the first year's coverage. The area shaded by each species group and for all groups combined is given in the left hand column of figure 2. Figure 3 shows the total area shaded at the time of cutting, and the amount of shade contributed by various species groups at 1-year intervals thereafter. This figure shows that the big increase in hardwood competition occurs during the first 3 years after cutting. By that time the area shaded by tree species has stabilized considerably, and the magnitude of pine release operation can be estimated.

Changes occurred over the 6-year period in the proportion of shade cover contributed by the various species groups.

The shrubby species:--The shrubby species show a steady year by year increase in area shaded. They shaded 2.9 percent of the ground in the fall of 1946 as compared with 9.9 percent in the fall of 1951. Shrubs occurred on 40 percent of the sample quadrats in 1946 and on 56 percent in 1951.

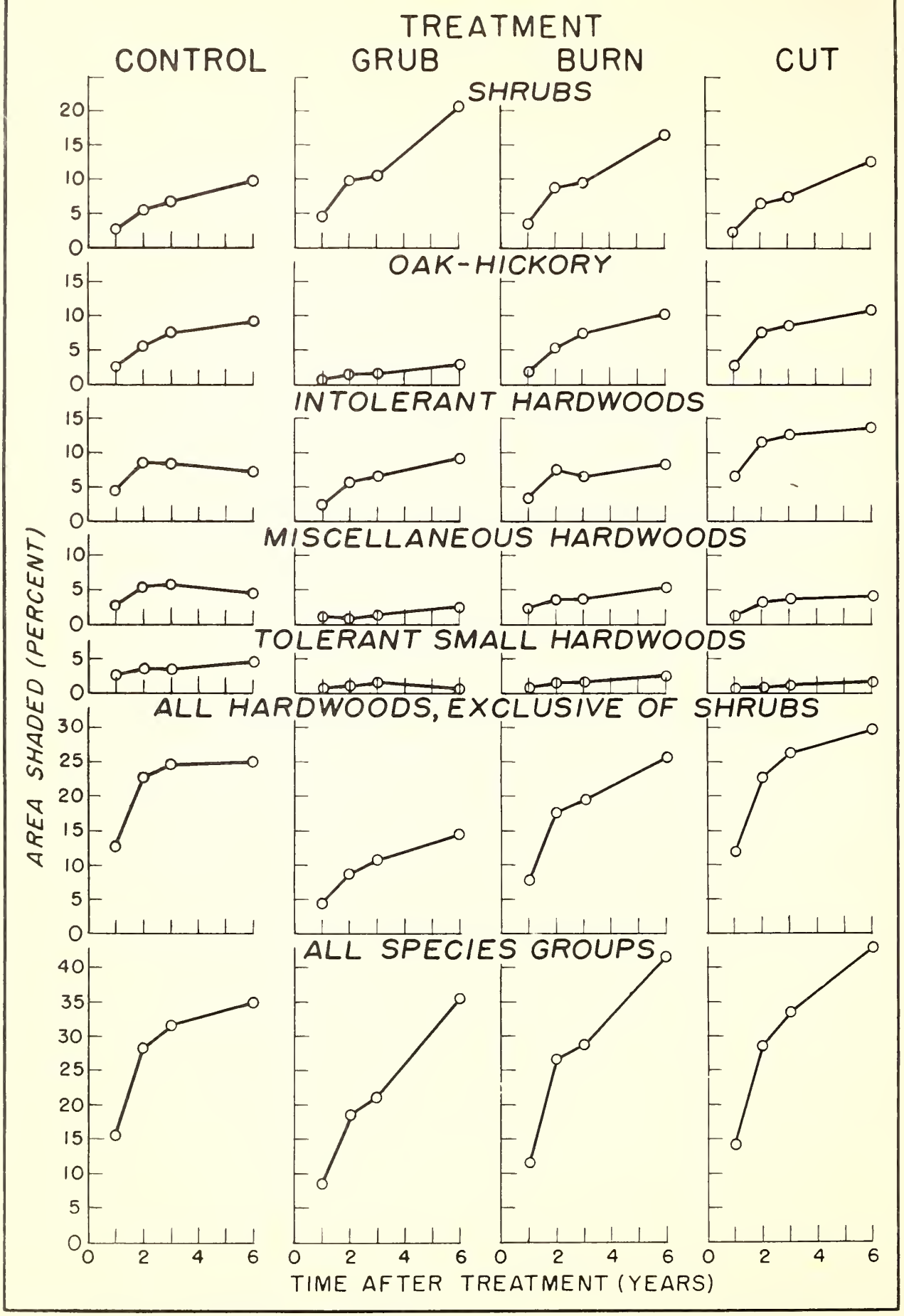

Figure 2.--Area shaded, by individual species groups, by tree species alone, and by tree species and shrubs at 1, 2, 3, and 6 years following various control treatments.

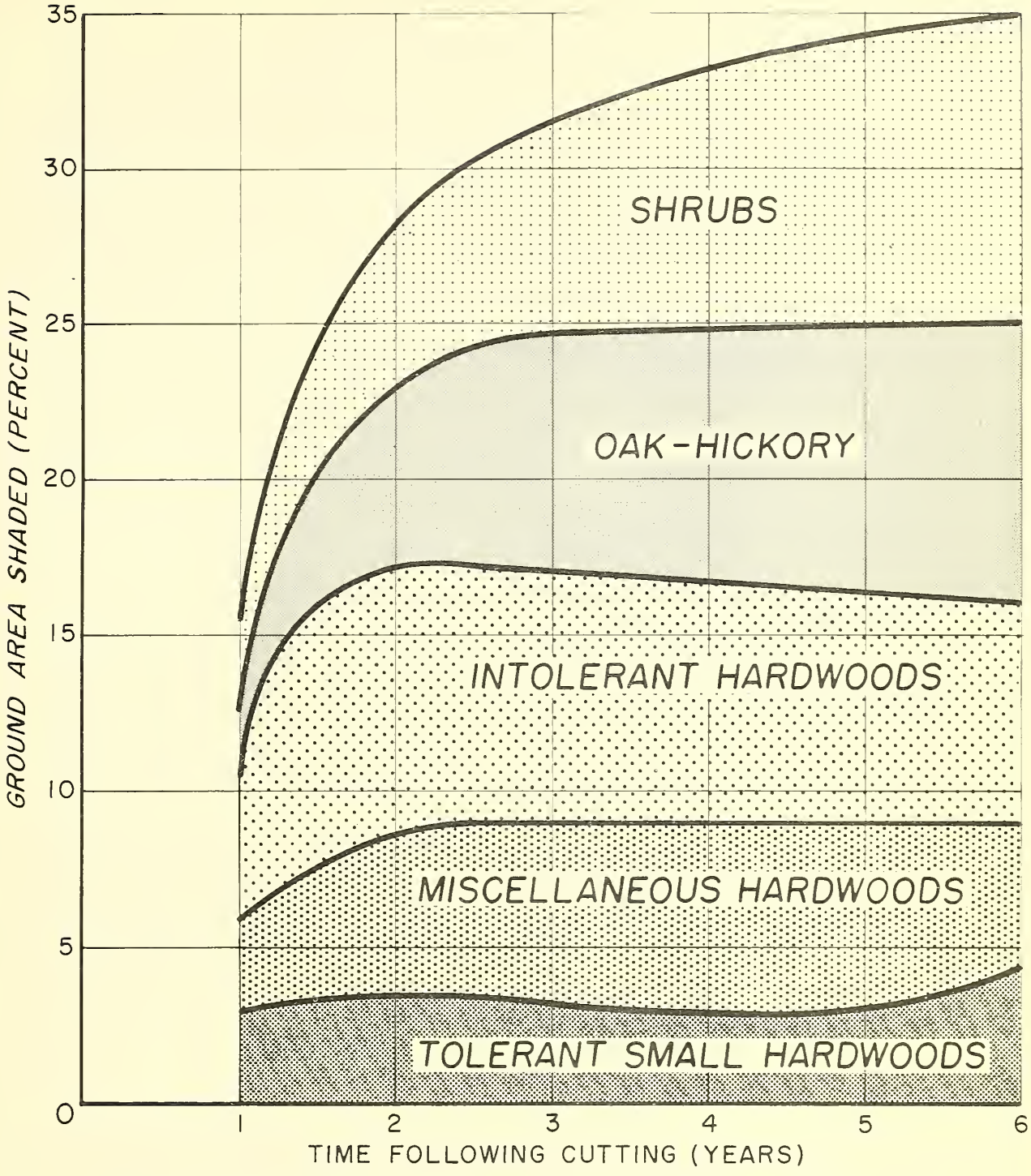

Figure 3.--Area shaded, by species groups on the untreated plots, measured at time of cutting and at 1, 2, 3, and 6 years after cutting the pine overstory.

Oak-hickory:--The oak-hickory association also made a steady year by year gain in area shaded. It increased from an initial cover of 2.5 percent to 9.1 percent by the end of the sixth year. The increase in area shaded was entirely a result of expansion of tree crowns present at the time of clear cutting. This species group expanded its crown more than all the other hardwood tree species combined. The oak-hickory association occurred in 18.8 percent of the quadrats in April 1946, and this number had not changed by the end of the 1951 growing season.

Intolerant hardwoods:--The intolerant hardwoods extended their shade cover during the second growing season, but their shading effect steadily decreased in subsequent years. Initially, they shaded 4.6 percent of the area, then they increased to 8.6 percent, but covered only 7.1 percent at the end of 6 years. The decrease in area shaded may have come about by reduction in number of sprouts and by invasion of shrubby species underneath the light shade of this species group, which changed the classification of the quadrat. This group occurred on 18.8 percent of the plots in 1951 and occurrence was not determined in 1946.

Miscellaneous hardwoods:--This species group, which consisted mainly of persimmon, black cherry, and sassafras, should not constitute much of a hazard to pine culture, because of the light shade it casts and small size of the individual trees. The area shaded showed only a slight increase during the 5-year period, from 2.9 percent to 4.6 percent. The frequency of occurrence increased from 17.5 percent to 31.2 percent, or nearly double. Invasion of new areas by persimmon accounted for a large portion of the increase.

Tolerant small hardwoods:--The group of species classified as tolerant small hardwoods was predominantly dogwood. Even though the area shaded by them increased relatively slowly (2.9 percent to 4.3 percent), and frequency of occurrence increased only from 7.5 percent to 10.9 percent, they nevertheless constitute an important impediment to pine reproduction. Their shade is dense and remains relatively low throughout the life of the individual tree or clump.

CHANGES IN SHADE LEVEL

The level of shade-casting crowns of the hardwoods has an important bearing on the establishment and development of pine seedlings. Under a dense low shade, pine seedlings cannot become established, but if seedlings are present in adjacent openings, they soon outgrow the low shade. Under a high shade level, pine seedlings can become established because of the side light, but they require release. One year after cutting and no treatment, 2.9 percent of the total area was covered by a shading layer at the 1-foot level, 4.5 at the 3-foot level, 2.7 at the 5-foot level, and 5.7 at the 6-foot-plus level. At the 1-foot level shrubs created the most shade; at the 3-foot level the intolerant hardwoods.

At the 5- and 6-foot-plus levels there was little difference between groups except that shrubs contributed little shade at these levels.

The area shaded by each species group at several shade levels 1 year after cutting is shown in table 1, and the proportion of low- and high-level shade at different periods in table 2. The level of shade shifted as the hardwoods and shrubs grew and the total area shaded increased. At 1 year after cutting nearly half of the shaded area was beneath a shade level of less than 4 feet. At 6 years, the proportion of shaded area under low shade had increased to nearly two-thirds (table 2). Figure 4 shows the condition of the hardwood understory immediately after clear cutting on a plot to be left untreated. Note the absence of cover in some areas and the large residual hardwoods that were left in other areas. Figure 5 shows an untreated plot 6 years after the pine overstory was removed. A release cutting will be necessary to obtain sufficient free-growing seedlings for satisfactory stocking.

Table 1.--Area shaded by species groups at different shade levels 1 year after clear cutting

(In percent of total area shaded)

Species group	Total area shaded	Average level of shade above ground at			
		1 foot	3 feet	5 feet	6 feet+
Shrubs	2.9	1.2	0.9	0.4	0.4
Oak-hickory	2.5	.5	.7	.2	1.1
Intolerant hardwoods	4.6	.4	2.0	.6	1.6
Miscellaneous hardwoods	2.0	.5	.5	.7	1.2
Tolerant small hardwoods	2.0	.3	.4	.8	1.4
Total	15.8	2.9	4.5	2.7	5.7

Table 2.--Area under low and high shade levels at various periods after clear cutting with no cultural treatment

(In percent of total area shaded)

Shade level	1 year	2 years	3 years	6 years
Low (1-4 ft.)	7.4	12.1	10.5	22.8
High (4 ft. plus)	8.4	16.1	21.0	12.1
Total	15.8	28.2	31.5	34.9

Figure 4.--Untreated plot immediately after clear cutting the pine overstory. Note large residual hardwoods in some areas and absence of hardwoods in others.

Figure 5.--Untreated plot with heavy overwood 6 years after clear cutting the merchantable pine. A release cutting will be necessary to obtain sufficient free-growing seedlings for satisfactory stocking.

UNDERSTORY HARDWOOD BEHAVIOR FOLLOWING GRUBBING, BURNING, AND CUTTING TREATMENTS

The cultural treatments had varying effects on the hardwood and shrub cover as shown in the three columns to the right in figure 2. The rate of spread of shade cover, the changes in various species groups, and the changes which occurred in shade levels following treatments are described below.

CHANGES IN AREA SHADED AND FREQUENCY OF OCCURRENCE

At the end of the first growing season, the grubbing and burning treatments show a biologically significant decrease in hardwood shade cover, exclusive of shrubs, as compared with the check and the cutting treatments. For the grubbing treatment the reduction in hardwood coverage extended to the sixth growing season. For the burning treatment the reduction in shade cover from hardwood species, though relatively small, is still evident in the second and third year after treatment. As expected, the grubbing treatment even after 6 years still shows a greater reduction in hardwood shade cover than does the burning treatment at the end of the second year. The cutting treatment proved to be a stimulus, rather than a deterrent, to hardwood spread. Hardwoods receiving the cutting treatment and those burned did not show tendencies of leveling off in their rate of spread during the last several years as did the check.

Shading from newly invading shrubs, especially after the third growing season adds a complication not anticipated in the experimental design. The majority of the shrubs are invading open land, but some are invading underneath the existing hardwood cover. All treatments increased the shrub cover over that of the untreated plots, especially in the case of the grubbing and burning treatments.

In general, the treatments had only minor effects upon the successional trend although they obviously reduced the number of plants. Grubbing provides the exception to this generalization in that the shrubby species were favored by this treatment, as shown in table 3.

Shrubby species:--Accelerated shrub invasion took place under all treatments in the first year following cutting. This trend continued through the sixth year, at which time the grubbed plots had twice the shade cover of the check. The cutting treatment displayed the least gain over the check; the burning treatment produced results intermediate between the grubbing and cutting treatments. There was also a marked

increase in the frequency of occurrence of shrubs following all treatments. The most common shrubby invader under the grubbing treatment was sumac, with a frequency of occurrence of 83.8 as against 41.2 on the check plots. The shade produced by shrubs was low and light.

Oak-hickory.--While these species were unaffected by other treatments, the grubbing reduced the area shaded to about one fourth that of the other plots the first year. Grubbing up the rootstocks retarded reproduction until at least the sixth year, at which time frequency of occurrence was about the same as for other treatments (table 3), though the shaded area was still much reduced.

Table 3.--Frequency of occurrence[1/] of understory hardwood species groups on treated and untreated plots 6 years after cutting the overstory

(In percent of total plots)

Species group	Treatment			
	No treatment	Grubbing	Burning	Cutting
Shrubs	56.2	86.2	63.8	73.8
Oak, hickory	18.8	23.8	25.0	27.5
Intolerant hardwoods	18.8	42.5	25.0	52.5
Miscellaneous hardwoods	31.2	31.2	37.5	27.5
Tolerant small hardwoods	10.0	3.8	3.8	6.2
One or more species group	88.1	95.0	86.2	91.2

1/ Frequency of occurrence is defined as the percentage of quadrats examined on which the species or group is represented.

Intolerant hardwoods:--The area shaded by the combination ash, gum, and yellow-poplar on plots burned and grubbed did not differ radically from that of the control plots. On plots where they were cut only, the area shaded increased slightly over the controls. However, the change in occurrence was striking. Under no treatment they occurred on 18.8 percent of the plots, as contrasted with 52.5 on the cut plots. Some of this increase may be attributable to suckering of the species in this group.

Miscellaneous hardwoods:--This group contributed a small amount of shade, and the changes due to treatment are not important.

Tolerant, small hardwoods:--All treatments reduced coverage as well as frequency of occurrence in this group, which contributed a very small amount of shade.

CHANGES IN SHADE LEVEL

The levels of shade from both shrubs and hardwoods were compared with the check plots for each growing season and show that throughout the course of the study the control had more high shade and less low shade than any of the treatments. The comparison of shade levels is more reliable when based on the first 3 years after treatment, before secondary invasion of shrubs took place. The area of low and high level shade by treatment and time after treatment is given in table 4.

One year after treatment the grubbing, burning, and cutting treatment had 8.5, 10.9, and 12.0 percent, respectively, of the area shaded by hardwood under 4 feet, while the untreated area had but 7.4 percent. At the end of 6 years the untreated area had 22.8 percent under low shade, while the grubbing, burning, and cutting treatments had 28.1, 33.5, and 32.9 percent, respectively. All treatments drastically reduced the high shade above the 4-foot level. One year after cutting, the untreated area had 8.4 percent with high shade, while areas treated by grubbing, burning, or cutting had 0.1, 0.4, and 1.9 percent, respectively. After 6 years the untreated area had 12.1 percent under high shade, and the grubbing, burning, and cutting treatments had 7.1, 8.4, and 9.5 percent, respectively.

Reduction of high shade is important because pine grows fastest when in full light. If pine seedlings become established near areas of low shade they can often outgrow it and become dominant in a few years.

Table 4.--Areas under low and high shade levels at various periods for untreated plots and plots grubbed, burned, and cut

(In percent of total plot area)

Shade level and treatment	Time since treatment			
	1 year	2 years	3 years	6 years
Low (1-4 feet)				
No treatment	7.4	12.1	10.5	22.8
Grubbing	8.5	17.3	17.9	28.1
Burning	10.9	20.7	15.8	33.5
Cutting	12.1	18.4	16.4	32.9
High (4 feet plus)				
No treatment	8.4	16.1	21.0	12.1
Grubbing	.1	1.2	3.1	7.1
Burning	.4	5.9	13.0	8.4
Cutting	1.9	10.4	16.7	9.5

Figures 6 and 7 show plots at the time of treatment and 6 years later where hardwoods were cut and rootstocks grubbed up, and where hardwoods 2 inches and over were cut and the area broadcast burned.

The need for hardwood control measures when establishing pine is given in the following quotation from Station Paper No. 18, which reported the establishment of the study (footnote 2). "Without cleaning, as indicated by the number of free seedlings after 5 years of growth, loblolly pine planted in openings or without area preparation could not meet a standard of 600 free-growing seedlings per acre. Some brush or ground treatment is necessary, and the number of free seedlings appears to increase with intensity of treatment. Brush cutting alone is satisfactory, but 25 to 30 percent more free seedlings may be obtained with the additional treatment in burning or grubbing. Cleaning would assure well over 600 free seedlings per acre in any treatment class."

SUMMARY AND CONCLUSIONS

A study was made of the detailed facts concerning the behavior of understory hardwoods in the lower Piedmont following clear cutting of the pine overstory. The ground surface directly shaded by hardwoods and shrubs nearly doubled during the first 2 years following clear cutting. Thereafter, growth was at a slower rate, and by the end of the third growing season the percentage of hardwood coverage approached a constant, while shrubs seem to continue their spread at a reduced rate.

The various species groups differed in their reaction to release through harvest cutting. The release stimulated the spread of oak-hickory crowns present at the time of treatment, but did not increase occurrence of this species group. Shrubby species not only increased in coverage following release but also showed tendencies to increase in frequency and in number of stems after the third growing season. The intolerant hardwoods and the tolerant small hardwoods showed slight increases in their relative importance in the stand.

Several treatments to reduce hardwoods were compared. All the treatments increased the amount of low shade and decreased the amount of high shade as compared with the control. The changes were more pronounced with burning or grubbing than with cutting.

Cutting of all hardwood stems had no beneficial, lasting effect in reducing area shaded, level of shade, or number of stems. Hardwood cover caught up with that of the control areas almost during the first year and was much heavier than that of the controls at the end of the sixth year. Cutting of all hardwood stems had a tendency to increase the gum and yellow-poplar component, but otherwise had no effect on the successional trend.

Figure 6.--Grubbing all the hardwood rootstocks definitely reduced the area shaded during the first 3 years and the shade was at a low level thereafter. It removed all the tall-growing hardwood species, but shrubs invaded the area and made twice as much shade as the shrubs on the untreated plot. Above, plot at the time grubbing treatment was applied. Below, an area 6 years after hardwood rootstocks were grubbed up. Note the absence of high shade cover.

Figure 7.--Cutting hardwood stems over 2 inches d.b.h. followed by a single early spring burn resulted in a temporary reduction in total area shaded and in the level of shade. This beneficial effect occurred through two growing seasons, after which it disappeared. Above, an area where hardwoods have been cut and burned. Below, 6 years after cutting and burning. Note the large number of free-growing seedlings even though there are numerous small hardwoods.

Cutting of stems to a 2-inch minimum d.b.h., followed by a single burn in the early spring resulted in a temporary reduction of total shade cover during the first year. Reduction of shade cover from tree species alone was still evident at the end of the second and third year following treatment, but by the end of the sixth year the area shaded exceeded that of the control and continued to spread. The reduction of the high level of shade lasted through two growing seasons following treatment. Burning did not significantly change the successional trend, although it increased the shrubby representation. As a silvicultural tool for pine culture, its total beneficial effect extended through two growing seasons on these plots.

Grubbing of the hardwood root stocks reduced total shade coverage during the first 3 years and the treatment effect lasted through the sixth year. It also had a lasting effect on lowering the level of shade. The treatment influenced the species composition more than any other treatment by reducing the small, tolerant hardwood and the oak-hickory association. However, on the grubbed plots the shrub cover became double that of the control.

The applied aspects of this study were discussed in an earlier station paper (see footnote 2), which described the effect of the hardwood control treatments on the success of planted pine seedlings, and discussed their use in management.

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